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COMPUTING MACHINERY

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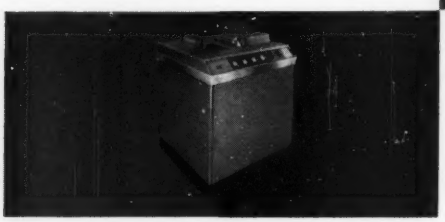

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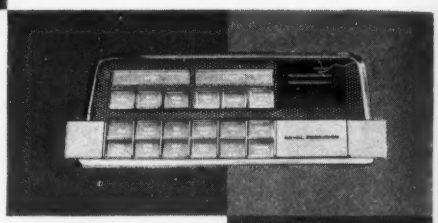

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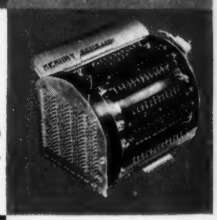

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By arrangement with the office of Naval Research, U. S. Navy Dept., the Digital Computer Newsletter issued quarterly by that organization is reprinted in its entirety as a supplement to the Communications.

OFFICIAL NOTICES

SOCIETY AND COUNCIL NOTES

Reciprocal Journal Arrangements with British Computer Society

The Council of The Association for Computing Machinery has approved arrangements whereby members of the British Computer Society may subscribe through their local society to our publications at reduced rates and reciprocal benefits are extended to ACM members. The rates applicable are as follows:

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The above rates are based on rates of exchange ruling at 31 July 1958. The arrangements for dollar exchange are subject to Bank of England sanction.

MEMBERSHIP STATUS OF THE ACM

During the month of September the Association passed a milestone in passing the 4000 mark of active, paid-up members. As of September 30, 1958 there were 4017 members of the ACM. In addition there are 767 individual and institutional subscribers to the publications of the Association.

LETTERS TO THE EDITOR

Dear Editor:

I would like to report information gained as a result of my recent visit in September to Regnecentralen, the Danish Institute of Computing Machinery, Danish Academy of Technical Sciences, Bjerregarrdsvej 5, Copenhagen Balby, Denmark.

I was cordially received by Mr. Niels Ivar Bech, the laboratory director, who took me on a tour of the DASK, the Danish machine, a progeny of the Swedish BESK, and thus remotely inheritor of the original Princeton computer characteristics.

This machine has a high speed memory of a Swedish design of 1024 40-bit words of magnetic cores. The cores were manufactured by General Ceramics. In addition the machine had two magnetic drums of Swedish manufacture, with electronic track switching, each with 128 tracks, each track with 32 words, for a total of 8192 words.

The machine is more compressed than the BESK, having two bays. The addition time is 56 microseconds, multiplication time 336 microseconds. It was built by 5 persons, two engineers with education at the Danish Technical High School (Technical Engineering Institute) and two electrical engineering technicians and one mechanical engineering technician.

The instruction code, similar to Princeton-type logic, has index-modification by means of three index-registers. Input is by paper-tape at 400 characters/second, and also with a Bull punch-card reader. Of special interest is the input-output buffering device, in which cards are read twice for checking, all-transistorized but using 17 tubes to connect to the machine. It uses 450 transistors (Philips low-frequency OC-76 and OC-45), 450 diodes (Delco 4N41 power) and 5000 magnetic cores (Philips). Facit printed circuits are used. There is a shift register consisting of one core and one transistor per stage. This device translates card holes to give both an internal machine card-image and a binary-coded decimal representation of numbers.

An Ampex FR400 magnetic tape unit is to be added soon, with circuitry of their own design. A version of the IT Compiler is now being written for this equipment.

A similar machine has been built in Sweden for the Swedish aircraft firm SAAB. Quantity production of a model with addition and multiplication speeds of 40 and 240 microseconds is to be produced beginning this fall by Facit in Stockholm at a rate of 2 or 3 each year.

It was my impression that the equipment was well designed, the morale of the group high, and their knowledge of British and American technology (as well as Swedish) quite good. I would recommend, on the basis of this short visit, that other European travelers visit both Copenhagen and Sweden for a glimpse of a flourishing computer technology not generally known too well in the United States.

Very truly yours,

JOHN W. CARR, III
University of Michigan

JWC:jp

TECHNIQUES DEPARTMENT

Editor's Notes:

This month's issue includes a rework of the chart on machine language simulation originally published in Issue 2. Some new information has been obtained which warrants a re-issuance. Further information is welcomed; just write details or send manuals to this department. Simulators which are thought to exist but for which I have no information are:

650 on the 704	MURA
650 on the 701	Chance-Vought
650 on the 205	(Believed to be AVCO)

Some information has been contributed on simulation of non-machine language on a different computer than that for which it was originated, but this may be considered a writing a specific processor for that language upon that particular machine. Some cases are:

LANGUAGE	FOR	PRODUCED BY	ORIGINAL MACHINE	PRODUCER
Speedcode	704	Convair	650	Redstone Arsenal
FLAIR	704	Convair	650	Lockheed MSD, Georgia
KISS	704	Computer Usage	650	Chrysler
BELL	205	Shell Devel. Corp.	650	Bell Telephone
	220	Burroughs	650	Bell Telephone
	704	IBM Endicott PDL	650	Bell Telephone
FORTRAN	205	NOL Corona	704	IBM
	220	Burroughs	704	IBM
	705-1, 2, 3	IBM	704	IBM

Information of the following coding systems has been added to the A.C.M. library,* and certain new systems are noted for which no information is available yet:

COMPUTER	NEW SYSTEM ADDED	NEW SYSTEM—DO NOT HAVE	
704	KOMPILER 3		
	MYSTIC		
701	BACAIC	BAP	
	PACT I		
650	BACAIC	KISS	
	RUNCIBLE		
	MYSTIC		
1103A	BOEING	APT	
	MYSTIC		
UNIVAC	UNISAP		
205		DOW	SPAR
		ANCP	BELL
		SHELL	
LARC		K5	SAIL
Ferranti Mercury	AUTOCODING (Norway)		

Preview of Coming Attractions: If all goes well, the next two issues should contain:
Preliminary Specification for the International Algebraic Language.
An extensive collection of nuclear code abstracts for various computers.

* See issue No. 8.

SIMULATION PROGRAMS—MACHINE LANGUAGE

COMPUTER BEING SIMULATED	COMPUTER ACTING AS SIMULATOR	SPEED RATIO — TO —		LIMITATIONS	PRODUCED BY	DATE COMPLETED
709 2500 or 6500 words, n tapes	704—4 or 8K n tapes	1	30	Will not simulate timed I–O, DSC transfers, BTT, etc.	IBM Applied Programming	Spring 58
704	701—4K	1	15–120	3000 word program, no copy instruction, limited I–O	United Aircraft, Hartford	Spring 55
704	701—2K, drum	1	100–500	Some	RAND Corp. (SHARE distr.)	Fall 55
705 TCU	705 TRC —20K or 40K	1	3–8	Some	IBM Applied Programming (Auto-conversion program replaces)	Fall 57
705—20, 40K	702—10K, drum	1	6–20		IBM Applied Programming	Summer 55
702—10, 20K	705—20, 40K	1	4–16	Some	IBM Applied Programming	Spring 57
650—All mod.	704—8K, 6 tapes off-line equip.	5–8	1	None	Council for Economic and Industry Research	Fall 57
650—All mod.	704—8K, 2 tapes	4	1		General Electric, Lynn, Mass.	April 58
650—2K drum	705—20K	1	2–4		Std. Oil of Indiana (IBM 32-7763)	Spring 57
650—2K drum	705—40K, tapes	1	1–1.5	Uses Autocoder conversion	Prudential Life Insurance	Spring 58
650—2K drum	1103A—8K —4K	6 5	1 1	None	Remington Rand, St. Paul	Sept. 58
650—core, index reg., flt. point	650—2K drum	1	10–20		IBM Los Angeles, 650 Library No. 2.0.011 (FIASCO)	Aug. 56
650	220	1	1–2	Not handle Ramac, tape, inquiry	Burroughs Corp., ElectroData Div.	Aug. 58
220	205—4K	1	170	Mag. tape input not simulated, 2800 word program limit.	Burroughs Corp., ElectroData Div.	Feb. 58
205	220	1–2	1	None	Burroughs Corp., ElectroData Div.	Aug. 58
205	650—2K drum			≤1000 consecutive locations	Shell Oil Co. (PROXY)	Spring 58
M460	1103	1	1000	No input-output instructions	Remington Rand, St. Paul	Jan. 57
UNIVAC II—2K	UNIVAC I—1K	1	100–150	Limited to 700 word program	Remington Rand, New York	Winter 56
LARC	UNIVAC I	1	10,000	For all LARC memory only	Remington Rand, Philadelphia	Fall 58
LARC	UNIVAC I II	1 1	10,000 5,000	200–500 word LARC program 1200–1500 word program	David Taylor Model Basin	Spring 58
TYDAC	UNIVAC I, 650	No basis			Case Institute of Technology	
TYDAC	704	No basis		No card-punching	Convair (SHARE distribution)	April 58
TYDAC	650	No basis		Some differences in detail	University of Rochester	June 58

THE USE OF COMPUTERS IN INSPECTION PROCEDURES

MERVIN E. MULLER, Princeton University and the I.B.M. Corp.

Summary:

Methods are presented for using a computer to prepare inspection procedures according to certain stratified random sampling plans.

1. *Introduction.*

Many situations exist where it is necessary to inspect a set of items so as to determine their quality, reliability, performance characteristics, or stock levels. Due to cost and time considerations it is often necessary to inspect the items on a sampling basis. The problem of selecting a sample for inspection, and the problem of describing the inspection procedures associated with the items selected, can be time consuming, expensive, and subject to human error. These problems can be solved efficiently and reliably with the help of electronic computers.

Two types of stratified random sampling plans which may be conveniently adopted to computer operation are considered below. It will be shown how a computer can be used to determine which items are to be inspected to satisfy those plans. The program may provide that certain items always be included for inspection. Further, the program may also specify the inspection procedures for the items which are to be inspected.

The use of stratified sampling plans is applicable to a wide variety of situations. The stratification of a set of items into sub-sets may be accomplished in any of several different ways. Frequently, the set of items from which a sample is to be drawn can be naturally divided into sub-sets of items. For example, a manufactured product which consists of N items or parts frequently can be viewed as consisting of a certain number of sub-assemblies, say k in number. The ith sub-assembly will consist of n_i parts and the sum of the numbers of parts in all k sub-assemblies equals N, (i.e. $\sum_{i=1}^{k} n_i = N$). In other situations, the final product may not consist of k distinct sub-assemblies, but its components can still be classified as if each of the N items belongs to one of k categories. This classification into categories could come about according to some statistical criterion, such as the variability of the quality of the items, or according to criteria such as the importance of the items for the functioning of the product, or according to some cost, availability, or usage criterion. In other instances, such as verifying an inventory consisting of N items, the set of items can be viewed as again consisting of sub-classifications determined by a desired set of criteria.

There can be several criteria for specifying a stratification of items. The criterion for the selection of the number and type of sub-divisions may or may not be of a statistical nature. Further, the specification of the size of the sample can be subject to several criteria. Detailed descriptions of the statistical treatment of these problems, and of the gains to be achieved by stratification, are well presented in reference [1].

In the sequel it will be assumed that N items are classified into k sub-sets, or strata, and the ith sub-set consists of n_i items, ($i = 1, 2, \ldots, k$). The problem is to select a stratified random sample, (i.e. select a specified number of items at random from each sub-set). The mathematical aspects of this problem will be considered in Section 2. Section 3 considers the use of computers to specify the inspection instructions, and Section 4 contains a discussion, including flow diagrams, for a general machine program.

2. *Selection Plans.*

In this section the underlying mathematical method is given for determining a sample. [Ref. 3]

Consider a system S containing N components which are classified into k sets $s_1, s_2, \ldots, s_k$, where the ith set, s_i, has n_i components, and $\sum_{i=1}^{k} n_i = N$. It is desired to inspect L components. Furthermore, it is desired to select a random sample for inspection such that *within* each set the components

have equal chances of being chosen, and the sample from the ith set will contain Lp_i components, either on the average (Plan 1), or else exactly (Plan 2), where each $p_i \geq 0$, and $\sum_{i=1}^{k} p_i = 1$. For convenience, and without loss in generality, it can be assumed that the items of S are numbered consecutively from 1 to N.

Given N, L, $s_1, s_2, \ldots, s_k$, and $p_1, p_2, \ldots, p_k$, a sample can be specified by the following procedure:

2.1. Select a "random number", r, in the interval [0, 1]. Satisfactory procedures exist for the machine generation of pseudo-random numbers, (see the discussion in section 4.5.1).

2.2. Given this randomly selected number r, test to determine the sub-interval to which it belongs, where the sub-intervals are $(0 \leq r < p_1), (p_1 \leq r < p_1 + p_2), \ldots, (\sum_{j=1}^{k-1} p_j \leq r \leq 1)$.

2.3. Having determined the appropriate sub-interval, say the ith, transform r to an integer I (r), defined by:

(2.3.1) $I(r) = [a_i + b_i r] + 1$ where [ ] denotes the largest integer in $a_i + b_i r$,

$$a_i = \sum_{j=0}^{i-1} n_j - b_i \sum_{j=0}^{i-1} p_j, \qquad i = 1, 2, \ldots, k,$$

$b_i = n_i / p_i$, and $n_0 = p_0 = 0$.

2.4. For Plan 1, steps 1 throuph 3 should be repeated L times.

2.5. For Plan 2, steps 1 through 3 should be repeated until there are exactly $[Lp_i]$ distinct selections for each of the k sets. As soon as a set is filled, additional items to be included in it are rejected.

3. *Inspection Instructions.*

The purpose of this section is to present several procedures for associating inspection instructions with the particular items which are selected by the computer for inspection. It is assumed that for each item subject to the inspection plan there exists a specified procedure for inspecting that item. The inspection instructions can be available in any of several forms.

3.1 *Computer selection—Manual specification.*

3.1.1. The computer determines, and presents as output, information specifying those items which are to be inspected.

3.1.2. The person engaged in executing the inspection procedures consults:

(a) a listing of the computer output to determine which items are to be inspected, and

(b) a catalogue of inspection instructions to find the inspection and recording procedures which are associated with these items.

It should be kept in mind that with proper format specifications, space can be provided on the computer output listing so that results of inspection may be recorded directly on the listing, by manual addition. If a set of designation headings for inspection results is available on cards, then these listings could be prepared by collating them with computer card output. If the collating operation is done internally by the machine, it will be considered a computer selection and a computer specification approach.

3.2 *Computer selection—Computer specification.*

The computer:

(a) determines and presents output information specifying those items which are to be inspected, and

(b) presents an indication of the information to be recorded at the time of the inspection. This approach is tantamount to the computer having stored internally, as a minimum, at least the recording-format part of the inspection catalogue.

3.3 *Computer selection—Computer specification, with feedback.*

This procedure is similar to procedure 3.2, except that the program is generalized so that it can maintain records concerning the results of previous inspections for subsequent use. For example, statistical records may be kept regarding the effectiveness of various types of inspection procedures (such as the difference in effectiveness between a dynamic test and a static test). Likewise, the effectiveness of various sampling plans could be subject to analysis.

Notes: 1) In all of the above approaches it should be understood that while the computer might select the items to be inspected in many different arrangements, the final output of the program would list the items to be inspected in an order that is reasonable for carrying out the actual inspection. (See section 4.4.)

2) While approach 3.3 is feasible with existing computers, this plan is of such a general nature that to be meaningful it would have to be programmed relative to specific goals and for specific areas of application. Consequently, only the possibility of having feedback procedures is being emphasized here.

4. *Computer Program.*

This section contains discussion of a general machine program, including a relevant flow diagram. The flow diagram is presented so that it can serve as a basis for planning a program on one of several computers.

See page 10 for Flow Diagram.

The following sub-sections are an explanation of the major steps of the flow diagram, Figure 1.

4.1 *Parameter Inputs.*

Inputs to the program are N, L, s_1, s_2, . . . , s_k, and p_1, p_2, . . . , p_k, and the choice of sampling Plan 1 or 2. Constants for the random number generator (see 4.5.2) are also inputs at this stage.

Situations may arise where, for either sampling plan, one may also desire to assure that certain sub-sets, or certain specific items are always inspected, i.e. 100% sampling. These situations can be handled by either of the following procedures: (1) separate the items subject to 100% sampling inspection before the rest of the data are entered as input, and then list the sampling inspection information relevant to these items with the rest of the computer output, or (2) specify the items for which 100% inspection is desired and have the editing feature of the machine program (4.3.1) handle these special items.

4.2 *Data Inputs.*

The item numbers (or a classification code) are input from either cards or tape. If the program is to prepare the inspection record formats internally, then this phase of the program will also input this information. This might include, for example, designation headings and inspection control information relevant to each item subject to inspection. If this information is available on cards and the program is to be used on a computer with only card input-output, it is suggested that this information not be included in the data input. It is suggested that the cards be collated off-line with the output of the selection program. However, if the information is on tape or disks it is reasonable to have it assimilated internally as part of the computer program.

This phase of the program also includes the assignment of internal or external storage locations for each of the items of each sub-set.

4.3 *Editing and Updating.*

4.3.1 *Editing for 100% Sampling.*

In the event that it is desirable to inspect certain items 100% of the time, and in the event that these items are not classified into a separate group prior to step 2, (4.2), this phase of the program flags these items to be treated separately prior to preparation of the output. It also rearranges the remaining items into different sub-sets or categories.

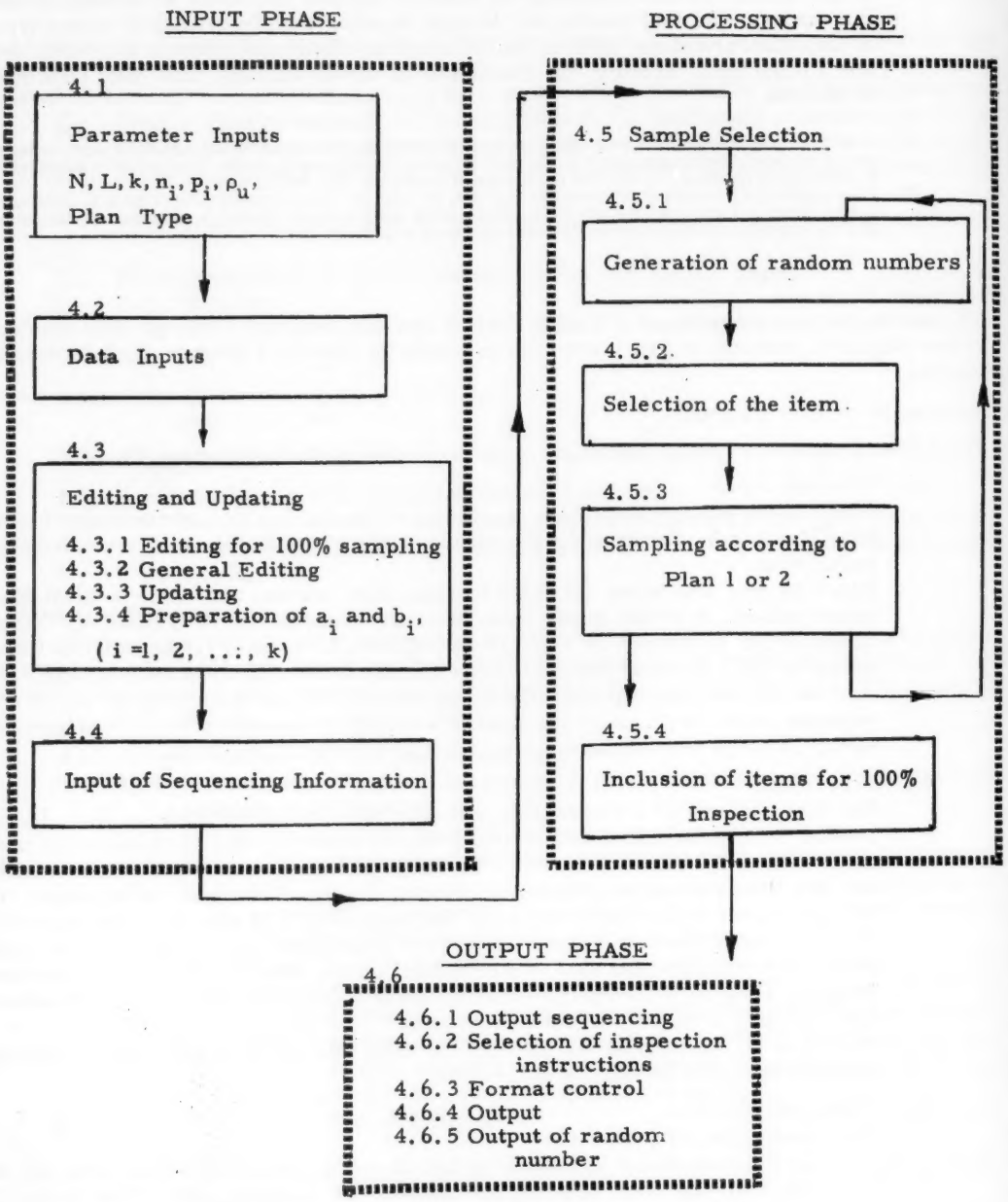
INPUT PHASE
PROCESSING PHASE
4.1
Parameter Inputs
N, L, k, n_i, p_i, ρ_u,
Plan Type
4.2
Data Inputs
4.3
Editing and Updating
4.3.1 Editing for 100% sampling
4.3.2 General Editing
4.3.3 Updating
4.3.4 Preparation of a_i and b_i,
(i =1, 2, ..., k)
4.4
Input of Sequencing Information
4.5 Sample Selection
4.5.1
Generation of random numbers
4.5.2
Selection of the item
4.5.3
Sampling according to
Plan 1 or 2
4.5.4
Inclusion of items for 100%
Inspection
OUTPUT PHASE
4.6
4.6.1 Output sequencing
4.6.2 Selection of inspection
instructions
4.6.3 Format control
4.6.4 Output
4.6.5 Output of random
number

FIG. 1

4.3.2 *General Editing.*
This phase of the program enables the following flexibility: Should it be desirable to reclassify items into sub-sets different from those given in step 2, (4.2) or should it be desirable to modify the inspection instructions to be associated with one or more items, then these modifications may be made without re-doing step 2, (4.2). This rearrangement is only practicable for a computer with external storage.

4.3.3 *Updating.*
This phase of the program has a purpose similar to (4.3.2), namely the option to rearrange data, except that this phase prepares or modifies the information tapes, or punches a new card deck of on-line, in order that, the next time the program is used to construct a sample, the data does not necessarily have to be edited.

4.3.4 *Preparation of Coefficients.*
Given the n_i and p_i, $(i=1, 2, \ldots, k)$, which may have been modified in steps 4.3.1 or 4.3.2, the coefficients a_i and b_i (see section 2) for equation (2.3.1) are computed and stored for later use.

4.4 *Input of sequencing information.*
The purpose of this section of the program is to call for the input of sequence or priority numbers for inspecting items, in the event that this information was not contained as part of the input at stage 2, (4.2).
In many applications there is a logical or preferred order in which items should be examined, which can be based on several criteria. Prior to using the machine program it would be good, in most applications, to determine an inspection ordering for the items. (This ordering is given independently of which of the items are selected to be included as part of the sample). This information may be included as part of the information associated with each item that is input at stage 2, (4.2). If this is the case, and if the final listing of the machine program is prepared from cards, then the sequencing can be done on a sorter. Otherwise, it will be necessary to sequence the items internally for the output tape, according to the specified ordering.

4.5 *Sample Selection.*
Reviewing the mathematical sample-selecting procedure presented in section 4.2, it is seen that it is necessary to: 1) generate random numbers in the interval [0, 1], 2) transform these random numbers according to equation 2.3.1, 3) repeat steps 1, 2, and 3 until a sample of size L is selected according to Plan 1 or Plan 2. Each of these three stages can be easily handled by the machine and the following sub-sections point out underlying details for the program.

4.5.1 *Generation of random numbers.*
The most satisfactory procedure known to date for generating pseudo-random numbers internally on a digital computer appears to be the method of "Residue-Classes", see for example references [2] and [4]. The necessary details for such a program on a binary or decimal machine are as follows:

4.5.1.1 *Binary machine.*
It is suggested that one obtain numbers from

$$\rho_{u+1} = \rho . \rho_u \pmod{2^p},$$
$$\rho_0 = 1,\ \rho = 5^{2k+1},$$

(actually ρ_0 can be any odd number such that $1 \leq \rho_0 \leq 2^{p-1}$) where p is the number of binary digits in a memory location. This sequence has period 2^{p-2}. Thus for the 704 one has $p=35$ and $k=6$.

4.5.1.2 *Decimal machine.*
It is suggested that one obtain numbers from

$$\rho_{u+1} = \rho . \rho_u \pmod{10^p},$$
$$\rho_0 = 1,\ \rho = 3^{4k+1}$$

(actually ρ_0 can be any odd number not divisible by 5 and it is recommended that k=0, 2, 3, or 4, since the period will then be $5 \cdot 10^{p-2}$), where p is the number of decimal digits in a memory location. Thus for the 650 one has p=10 and k=4.

4.5.1.3 *Summary on random numbers.*

It should be seen that regardless of whether the machine operates in a binary or decimal mode, the generation of pseudo-random numbers is accomplished in an easy and straight-forward manner. Each random number is obtained from the previous one by the recurrence relationship $\rho_{u+1} = \rho . \rho_u$ (mod 2^p or 10^p), where p denotes the number of digits in a memory location. The residue is obtained by carrying out the multiplication with double precision and the desired answer ρ_{u+1}, is the p least significant digits.

Each time the sub routine is entered it is necessary to have available the previous random number (ρ_u). In repeated use of the program, to avoid starting from the same random number each time the computer program is used, it is suggested that the last ρ_u generated be stored so that when the computer routine is finished outputting relevant sampling information it will also output the last random number generated. This number then serves as the input value of ρ_u the next time the machine program is used.

4.5.2 *Selection of the items.*

The transforming or mapping of a random number generated in the last phase of the program to an integer which corresponds to an item number requires that the proper coefficients, a_i and b_i specified by equation 2.3.1 of section 2, be selected. Under the assumption that the items of each sub-set have been assigned consecutive storage locations (either in part 2 or 3) then this phase of the program is rather straight-forward. Given a random number the coefficients (which have been stored in consecutive locations, one block for the a's and another block for the b's) are selected by shifting the random number an appropriate number of positions (the exact number depends on the p_i's and k). If the computer has index registers this shifted random number is placed in an index register in order to select the proper coefficients, otherwise this shifted random number is used to modify an address location in order to select the appropriate coefficients.

4.5.3 *Plan 1 or Plan 2.*

To achieve the objectives of Plan 1 or 2 and to insure that an item is only selected once in each sample of size L the following rather simple procedure is suggested. (It should be kept in mind that other approaches are possible.) Prior to the selection of any item the initialization aspect of the program will set the sign of each item number positive. Upon selection of this item for possible inclusion in the sample the program tests the sign of the item number. If it is positive it accepts the item as part of the sample; it then sets the sign of this item number to be negative. If it is negative it rejects the item for inclusion in the sample again, and proceeds to generate another random number. This procedure insures that an item will not be allowed to appear twice during the generation of a given sampling plan on the computer.

4.6 *Output Controls.*

4.6.1 *Output sequencing.*

In the event that the sequencing of the items to be inspected is done internally on the computer, this phase of the program uses the sequencing information input at stage two or stage four of the program.

4.6.2 *Selection of the inspection instructions.*
In the event that the selection of the inspection instruction is to be done internally on the computer, this phase of the program merges the items to be inspected with the instructions associated with them.

4.6.3 *Format control.*
The control of the format of the output is taken care of at this stage. This might include the output of a tape to prepare an off-line listing, or the punching of cards. Further, the format control program could involve the option of output cards for mark-sensing so that the results of the inspection could be noted on the cards creating the output listings. This might be especially suitable in the inspection of inventory or bills of material.

4.6.4 *Output of random number.*
In accordance with section 4.5.1.3 the last random number generated is punched out to be used as a new starting value the next time the program is used.

4.7 *Feedback Evaluation.*
This is a reminder that one may augment a program to include the evaluating of inspection techniques. The inclusion of this phase into the present program will not be considered until some experience has been gained with the other parts.

Acknowledgments:
The author wishes to express his appreciation to Dr. J. N. Froomkin and Mr. E. McGaughy for their counsel concerning the manuscript.

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TWO SQUARE-ROOT APPROXIMATIONS

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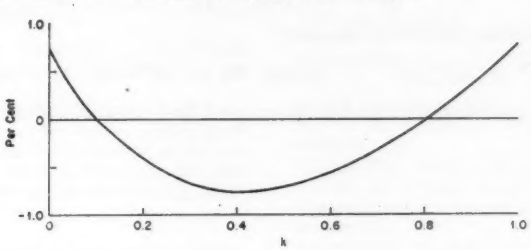
The number, N^2, whose root is desired may be expressed as the sum of two numbers, A_1^2 and B^2, such that A_1^2 is a known square and $B^2 \leq A_1^2$. Let the ratio, B^2/A_1^2, be denoted by k, and the approximation to N, by N^*.

The first approximation, which is good to 0.75 per cent, is

$$N^* = A(1.0075 + 0.4173\ k).$$

The error function is given below for the relative error, $(N^* - N)/N$.



The second approximation, which is good to .064 per cent, is

$$N^* = A(1.000625 + 0.485025\,k - .07232\,k^2).$$

Its error function is as shown below.

It is useful to have a set of N_i^2 such that $N_{i+1}^2 < 2N_i^2$ for all i. The minimum number of such N_i^2 which will span the range from .01 to 1 is seven. Such a set of N_i^2 and their roots is given below.

N_i^2	N_i
.010000	.100
.019881	.141
.039601	.199
.078961	.281
.157609	.397
.314721	.561
.628849	.793

Editor's Note:

The form given here requires division in the calculation of the initial approximation. For certain computers, division is a lengthy process compared to multiplication. In these cases a modification is useful. For example, the first formula may be expressed:

$$N^* = A\left[1.0075 + .4173\,\frac{(N^2 - A^2)}{A^2}\right] = \frac{.5902\,A^2 + .4173\,N^2}{A}$$

which for the various segments reduces to the form

$$N^* = a_0 + a_2 N^2 \qquad \text{where} \quad a_0 = .5902\,A, \quad a_2 = .4173/A$$

This reduces the method to essentially the linear segment first approximation found in the first issue of the Communications.

STANDARDS

The following is a continuation of the Standard Department's publication of the "Glossary of Computer Engineering and Programming Terminology" from the Aberdeen Proving Ground, *BRL Report No. 1010.* The department earnestly solicits all comments concerning the proper use of terms, definitions, ambiguities and unusual meanings and applications.

TAPE, PROGRAM
a tape which contains the sequence of instructions required for solving a problem and which may be read by the computer.

TERNARY
pertaining to the system of notation utilizing the base of 3, employing the characters 0, 1, and 2.

TEST, CRIPPLED-LEAP-FROG
a variation of the leap-frog test, modified so that it repeats its tests from a single set of storage locations rather than a changing set of locations.

TEST, LEAPFROG
a program designed to discover computer malfunction, characterized by the property that it performs a series of arithmetical or logical operations on one group of storage locations, transfers itself to another group of storage locations, checks the correctness of the transfer, then begins the series of operations over again. Eventually, all storage positions will have been occupied and the test will be repeated.

TETRAD
a group of four, usually four pulses, in particular, a group of four pulses used to express a decimal digit, or a sexadecimal digit by means of four (binary) pulses.

TETRODE
a four-electrode vacuum tube containing a cathode, control grid, screen grid, and plate.

THERMISTOR
the thermistor is a solid state, semiconducting device made by sintering mixtures of the oxide powders of various metals. It is made in many shapes, such as beads, disks, flakes, washers and rods, to which contact wires are attached. As its temperature is changed, the electrical resistance of the thermistor varies. The associated temperature coefficient of resistance is extremely high, nonlinear, and negative.

THERMOCOUPLE
a device made up of two bi-metal joints (usually wires forming a closed loop) having the property that if the two junctions are maintained at different temperatures, a difference of potential is brought into existence equally distributed between the two junctions.

THREE-ADDRESS
see Code, Multiple-address.

THYRATRON
a hot-cathode, gas-discharge tube in which one or more electrodes are used to control electrostatically the starting of an unidirectional flow of current.

TIME, CODE CHECKING
all time spent checking out a problem on the machine making sure that the problem is set up correctly, and that the code is correct.

TIME, ENINEERING or SERVICING
all machine down time necessary for routine testing (good or bad), for machine servicing due to breakdowns, or for preventive servicing measures, e.g., block tube changes. Includes all test time (good or bad) following breakdown and subsequent repair or preventive servicing.

TIME, IDLE
time in which machine is believed to be in good operating condition and attended by service engineers but not in use on problems. To verify that the machine is in good operating condition, machine tests of the leapfrog variety may be run.

TIME, NO CHARGE MACHINE-FAULT
unproductive time due to a computer fault such as the following: (1) non-duplication, (2) transcribing error, (3) input-output malfunction, (4) machine malfunction resulting in an incomplete run.

TIME, NO CHARGE NON-MACHINE-FAULT
unproductive time due to no fault of the computer such as the following: (1) good duplication, (2) error in preparation of input data, (3) error in arranging the program deck, (4) error in operating instructions or misinterpretation of instructions, (5) unscheduled good testing time, run during normal production period when machine malfunction is suspected but is demonstrated not to exist.

TIME, PRODUCTION
good computing time, including occasional duplication of one case for a check or rerunning of the test run. Also, duplication requested by the sponsor; any reruns caused by misinformation or bad data supplied by sponsor. Error studies using different intervals, convergence criteria, etc.

TIME, STANDBY UNATTENDED
time in which the machine is in an unknown condition and not in use of problems. Includes time in which machine is known to be defective and work is not being done to restore it to operating condition. Includes breakdowns which render it unavailable due to outside conditions (power outages, etc.).

TIME, SYSTEM, IMPROVEMENT
all machine down time needed for the installation and testing of new components, large or small, and machine down time necessary for modification of existing components. Includes all programmed tests following the above actions to prove machine is operating properly.

TRACK
in a serial magnetic storage element, a single path containing a set of pulses.

TRANSCRIBE
to copy, with or without translating, from one external storage medium to another.

TRANSDUCER
a device which converts energy from one form to another, e.g., a quartz crystal imbedded in mercury can change electrical energy to sound energy as is done in sonic delay lines in computer storage systems.

TRANSFER
to copy, exchange, read, record store, transmit, transport, or write data; to change control; to jump to another location.

TRANSFER, CONDITIONALLY
to copy, exchange, read, record, store, transmit, or write data or to change control or jump to another location according to a certain specified rule or in accordance with a certain criterion.

TRANSFER, PARALLEL
a system of data transfer in which the characters of an element of information are transferred simultaneously over a set of paths.

TRANSFER, SERIAL
a system of data transfer in which the characters of an element of information are transferred in sequence over a single path in consecutive time positions.

TRANSFER, UNCONDITIONAL
an instruction which causes the subsequent instruction to be taken from an address which is not the next one in the sequence in a digital computer which ordinarily obtains its instructions serially from an ordered sequence at all other times.

TRANSFORM
to change information in structure or composition without altering the meaning or value; to normalize, edit, or substitute.

TRANSIENT
a phenomenon experiencing a change as a function of time; something which is temporary; a build-up or breakdown in the intensity of a phenomenon until a steady state condition is reached; an aperiodic phenomenon; the time rate of change of energy is finite and some form of energy storage is usually involved.

TRANSISTOR
an electronic device utilizing semi-conductor properties to control the flow of currents from one source in one circuit by currents from another circuit, e.g. a triod transistor permits the control of current in one circuit by the use of a smaller current in another circuit, with the transistor common to both circuits.

TRANSLATE
to change information (e.g., problem statements in pseudo-code, data, or coding) from one language to another without significantly affecting the meaning.

TRANSMIT
to reproduce information in a new location replacing whatever was previously stored and clearing or erasing the source of the information.

TRANSPORT
to convey as a whole from one storage device to another.

TROUBLE-SHOOT
to search for a coding mistake or the cause of a computer malfunction in order to remove same.

TRUNCATE
to drop digits of a number of terms of a series thus lessening precision, e.g. the number 3.14159265 is truncated to five figures in 3.1415, whereas one may round off to 3.1416.

TRUNK
a path over which information is transferred; a bus.

TUBE, ACORN
a small vacuum tube designed for ultra-high-frequency circuits. The tube has short electron transit time and low interelectrode capacity.

TUBE, CATHODE-RAY
an electronic vacuum tube containing a screen on which information may be stored by means of a multigrid modulated beam of electrons from the thermionic emitter, storage effected by means of charged or uncharged spots; a storage tube; a Williams tube; an oscilloscope tube; a picture tube.

TUBE, WILLIAMS
a cathode ray tube used as an electrostatic storage device of the type designed by F. C. Williams, University of Manchester, England.

TWO-ADDRESS
see Code, Multiple-address.

TYPEWRITER, ELECTRIC
a hand operated electric powered individual character printing device having the property that almost every operation of the machine after the keys are touched by human fingers is performed by electric power instead of manual power; a typewriter powered by electricity, in all other respects the same as a manually powered typewriter.

ULTRASONICS
the field of science devoted to frequencies of sound above the human audio range, i.e. above 20 kilocycles per second.

UNCONDITIONAL
not subject to conditions external to the specific instruction.

UNPACK
to decompose packed information into a sequence of separate words or elements.

UNWIND
to code explicitly, at length and in full all the operations of a cycle thus eliminating all red-tape operations in the final problem coding. Unwinding may be performed automatically by the computer during assembly, generation, or compilation.

VALIDITY
correctness; especially the degree of the closeness by which iterated results approach the correct result.

VARISTOR
a passive resistor-like circuit element whose resistance is a function of the current through it or voltage across its terminals, i.e. the current through it is a non-linear function of the voltage across its terminals, hence the linear form of Ohm's Law is not obeyed; a self-varying resistance.

VERIFIER
a device on which a manual transcription can be verified by comparing a retranscription with it character-by-character as it is being retranscribed.

VERIFY
to check a data transfer or transcription, especially those involving manual processes.

WIRE, MAGNETIC
wire made of a magnetic material along small incremental lengths of which magnetic dipoles are placed in accordance with binary information.

WORD
a set of characters which occupies one storage location and is treated by the computer circuits as a unit and transported as such. Ordinarily a word is treated by the control unit as an instruction, and by the arithmetic unit as a quantity. Word lengths are fixed or variable depending on the particular computer.

WORD, INFORMATION
an ordered set of characters bearing at least one meaning and handled by a computer as a unit, including separating spacing, which may be contrasted with instruction words.

WORD-TIME
especially in reference to words stored serially, the time required to transport one word from one storage device to another. See also Access Time.

WRITE
to transfer information to an output medium; to copy, usually from internal storage to external storage; to record information in a register, location, or other storage device or medium.

ZERO
nothing; positive binary zero is usually indicated by the absence of digits or pulses in a word; negative binary zero in a computer operating on one's complements by a pulse in every pulse position in a word; in a coded decimal machine, decimal zero and binary zero may not have the same representation. In most computers, there exist distinct and valid representation both for plus and for minus zero.

ZERO-SUPPRESSION
the editing or elimination of non-significant zeros to the left of the integral part of a quantity before printing operations are initiated; a part of editing.

ZONE
a portion of internal storage allocated for a particular function or purpose; any of the three top positions of 12, 11 and 0 on a punch card. In these zone positions, a second punch can be inserted so that with punches in the remaining positions 1 to 9, alphabetic characters may be represented.

NEWS AND NOTICES

NATIONAL ACM

• The agenda for the next meeting of the National ACM Council at the EJCC in Philadelphia, December 3, 1958, will include the consideration of several interesting subjects carried over from the June meeting at Urbana, Illinois.

1) Final decision on the site of the 1960 Conference—The University of Wisconsin has proposed that the conference be held in Madison; Milwaukee has been suggested as an alternate; the St. Louis ACM Chapter and Seattle, Washington have also indicated interest in inviting the conference.

2) Discussion of a new name for ACM—Both the machinery and computational connotations in the present name seem no longer appropriate. Consideration will be given to the possibility of changing the name to reflect the society's position of linking mathematicians, logicians, and computer users.

3) Consideration of a committee's recommendations regarding a change to the ACM Constitution Preamble to include a statement of social interest.

4) Consideration of committee reports regarding representation of user groups on the ACM Council—Should, and how can, user groups become integrated with ACM?

5) Decision regarding the joint sponsorship by ACM and the Institute of Mathematical Statistics of a conference at Case Institute of Technology.

6) Consideration of recommendations for methods to improve the status of the National ACM treasury —publication costs have created a dilemma of expenses.

7) Further consideration of chapter relations—In particular, there is the question of national aid to local chapters.

• Many persons interested in the expanding activities of the ACM have inquired about the procedure for membership application. The application form provides for a membership with an effective date either retroactive to January 1, 19(n), or to be set ahead to January 1, 19(n+1). Back copies of all publications are supplied with a new membership effective January 1, 19(n). Dues are $6.00 per calendar year. The following schedule is allowed:

If Paid	*Amount Due*
January 1–July 1	Full dues—$6.00
July 1–October 1	Fifty per cent dues—$3.00
October 1–January 1	No dues—$0

• The National ACM will sponsor a session entitled "Adventures with Electronic Digital Computers," at the annual meeting of the American Association for the Advancement of Science to be held in Washington, D. C., December 26–31, 1958. This session, presided over by William F. Cahill of the National Bureau of Standards will include the following talks: "French to English by Computing Machine," by A. F. R. Brown, Research Associate, Machine Translation Project, Georgetown University, Washington, D. C.; "Musical Compositions by a Digital Computer," by Lejaran Hiller, Assistant Professor of Music, Department of Music, University of Illinois, Urbana, Illinois; "Computers and the Dead Sea Scrolls," by Paul Tasman, Manager of Data Processing, IBM World Trade Corporation, New York, New York; and "Capital Airlines Reservation System," by R. C. Douglas, Manager of Electronic Sales and Development, Capital Airlines, Washington, D. C.

ACM CHAPTER NEWS

Dallas-Fort Worth Chapter:

At the September meeting of the Dallas-Fort Worth Chapter a brief report on computing activities in its area was presented by each member installation. The following officers for the coming year were elected: President, D. Richmond of Texas Instruments; Vice President, G. P. Owen of Convair; Program Chairman, A. R. Mandelin of Chance Vought; Secretary-Treasurer, C. Hamilton of Temco.

Delaware Valley Chapter:

Membership in the Delaware Valley Chapter has passed the 110 mark and is continuing to increase. At the chapter's October meeting, held at the University of Pennsylvania, E. J. Goldfinger of the Applied Programming Department of IBM spoke on "Comtran," a new commercial compiler. Future events on the chapter's calendar are the Eastern Joint Computer Conference in Philadelphia and the annual banquet and election of officers for the coming year to be held in December.

Kansas City, Missouri, Chapter:

The Kansas City Chapter (not yet an "official" chapter) held its first social meeting on October 28, 1958. Dr. R. W. Hamming, President of ACM, spoke on "The Future of Computing."

Los Angeles Chapter:

At its October meeting the Los Angeles Chapter heard two representatives of the ElectroData Division of Burroughs Corporation—Mr. Irvin Marshall, Supervisor, Technical Services and Miss Janice Kibler, Educational Specialist, Publications and Training, speak on "Supermarket Battle Maneuvers—A Management Game," a recent demonstration in Palm Springs, California (see March, 1958 issue of *Communications*).

A plan to establish student computing groups in local universities has been proposed. If the national organization agrees to establish a student membership category, such groups could become official student chapters of the ACM.

San Diego Chapter:

At its September meeting, the San Diego Chapter heard Mr. W. Alexander, Chief Engineer and Assistant Manager of Stromberg-Carlson, San Diego Division, speak on "The Latest Developments of the Charactron and Its Applications."

At the October 16 meeting, Thomas Steel, head of the computing group of System Development Corporation, Santa Monica, California, spoke on "Computer Languages." Mr. Steel was a co-author of a paper entitled "The Problem of Programming Communication with Changing Machines—a Proposed Solution," published in the August issue of the *Communications*.

The chapter has established the following committees: Arrangements—C. Reid; Publicity—J. Iverson; Membership—T. Dines; Program—H. Englander, Chairman, assisted by C. Swift, T. Moffett, and W. Varner; and Education—F. Oglebay.

Representatives of the San Diego Chapter have now been designated at the following companies: Convair-Astronautics, Convair-San Diego, Navy Electronics Laboratories, General Atomic, Solar Aircraft, Ryan Aircraft, Rohr Aircraft, San Diego Gas and Electric Co., U. S. Navy Personnel Accounting Machine Installation, Stromberg-Carlson, San Diego State College, Palomar Research and Development Co., Kalbfell Electronic Co., and Convair (Commercial).

Syracuse Chapter:

At the opening chapter meeting for the year, over fifty members and guests were introduced to the MOBIDIC Computer by Dr. Gerard Salton, who is Head of Computer Applications Section, Sylvania Electric Company, Waltham, Massachusetts, and also an instructor in applied mathematics at Harvard University.

On October 29 the group again met to hear an address concerning the matching of applications with the proper size and type computer. The speaker for the evening was Mr. Ray E. Keefe, Manager of Data Processing Methods at IBM, Endicott, New York.

The November meeting was held in conjunction with the Syracuse Chapters of National Machine Accountants' Association and Systems and Procedures Association. Mr. James D. Gallagher, Administrative Assistant to the Manager of the Sylvania Data Processing Center at Camillus, New York, was the speaker.

UNIVERSITY ACTIVITIES AND EDUCATION PROGRAMS

• Dr. Alex Orden, Manager of Applied Mathematics for the ElectroData Division of Burroughs Corporation, has been named Director of the University of Chicago's Operation Analysis Laboratory. This laboratory utilizes both IBM and UNIVAC computers. Dr. Orden will also hold a faculty appointment as Professor of Applied Mathematics in the School of Business.

• Carnegie Institute of Technology has installed a RAMAC disc storage unit on its IBM 650.

• Dr. Frank G. Dickey, President of the University of Kentucky, has announced the establishment of a Computing Center (equipped with an IBM 650) at the University of Lexington, Kentucky as of September 1, 1958. Dr. John W. Hamblen, formerly Associate Professor of Mathematics and Director of the Computing Center at Oklahoma State University, has been appointed Director. The Computing Center, established for research and educational uses under the IBM Educational Contribution Program, will be under the general supervision of the Office of the Vice President. An advisory committee, with Dr. Leo M. Chamberlain, Vice President, as Chairman, includes the following: Dr. Merl Baker, Executive Director, Kentucky Research Foundation; Dr. Howard Beers, Head, Departments of Sociology and Rural Sociology; Dr. Aubrey Brown, Head, Department of Agricultural Economics; Dr. James Calvin, Head, Department of Psychology; Dr. Lewis Cochran, Acting Head, Department of Physics; Dr. Lyle Dawson, Head, Department of Chemistry; Dr. J. C. Eaves, Head, Department of Mathematics and Astronomy; Dean R. E. Shaver, Dean, College of Engineering; Dean H. E. Spivey, Dean, Graduate School; and Dr. Robert Stroup, Associate Professor of Economics.

• The Western Data Processing Center at UCLA has received its IBM 709. New participants in the Center are Brigham Young University, The Davis Campus of the University of California, and the Santa Barbara Campus of the University of California. The new 709 installation includes 32,768 cores, twenty on-line 729 tape units, two data synchronizer units (4 channels), 16,374 drum locations, card-to-tape, and tape-to-printer equipment, plus the usual input-output equipment. Cathode ray tube display and recorder units will arrive later.

• Dr. Donald LaBudde of New York University has accepted a position as Assistant Professor in the Department of Mathematics at Wayne State University, Detroit, Michigan. He will teach courses on automatic computers, using an IBM 650.

• Pomona College in Claremont moved into its new math and physics building in October. Included in the facilities is a Bendix G-15 installation under the direction of Drs. Chester Jaeger and Charles Fowler. The computer will be used for student instruction and research projects.

• Two UCLA departments, Psychology and Psychiatry, recently used the Western Data Processing Center's IBM 650 to assist in evaluating experimental approaches to student examinations and grading methods. Drs. Bertram Raven, Robert Stoller, and Robert Geertsma are directing the studies.

COOPERATIVE PROGRAMMING GROUPS

SHARE

Future SHARE meetings have been scheduled as follows: SHARE XII Meeting, February 17–20, 1959, Statler Hotel, New York City; SHARE XIII Meeting, August 18–21, 1959, Olympic Hotel, Seattle, Washington; and SHARE XIV Meeting, February, 1960, Los Angeles. It is probable that all future meetings will be officially four days in length.

UNIVAC Users Conference

Representatives of forty business and government organizations attended the UNIVAC Users Conference in Boston, Massachusetts, on October 20–21. A luncheon address was presented by Wassily Leontief, Director of Economic Research, Harvard University on "The Use of Large Scale Computers as an Aid in Management Decisions."

NEWS ITEMS

• General Kinetics, Incorporated, Arlington, Virginia has designed and built a magnetic tape tester for UNIVAC tape. The unit, which was built for the Army Map Service, includes transport system,

magnetic recording and reproducing heads, automatic punching assembly, electronic circuits and power supplies. Both six and eight inch reels are accommodated and tested automatically at 25 inches per second with 120 inches per second rewind. Testing simulates UNIVAC, unpunched defective regions are punched optionally, and counts are kept of the number of defects and the total tape footage. Higher speed operation with automatic punching during rewind is an optional feature.

• Bendix Aviation Corporation Computer Division recently announced the "CA-2," a new accessory to the G-15 digital computer which gives this computer punched card data processing capabilities formerly offered by only the more expensive machines. The CA-2 permits standard 80 column cards to be read or punched at 100 lines per minute. Computation can proceed during input or output, thus assuring maximum speed in overall operations. The complete system consisting of a G-15 computer, the CA-2, conventional card readers and punches, and a tabulator will lease for about $2,500 per month.

• Librascope Inc. of Glendale, California has available the Libratrol-500, a new control system developed around a rapid-response digital computer. The system provides a full range of process control—from accurately processing data that provides understandable information to a human operator, to complete automatic control of the entire process. The system has been designed on a building block concept for connection to existing equipment in any processing plant. A gradual changeover from manual process control to a completely automatic computer-controlled plant may be accomplished without replacing this system.

• A new type dime-size magnetic component, called a transient permanent magnistor, has recently been developed by the Potter Instrument Company, Inc., Plainview, New York. It is claimed that the new magnistor will make possible high speed printer systems two-thirds smaller than those now in use, and will cut the cost of many electronic computers by one-third. The magnistors are extremely durable and can be incorporated directly into data processing computer equipment circuits without provision for replacement; they will operate over a wide frequency range and have near "absolute reliability." Applications forecast for the component include automation control equipment, business data handling systems, magnetic tape systems, high speed printer systems, automatic volume control systems, and automatic on-off switching systems for thyratron actuated sign board. Specific digital applications include sorting and collation, coincidence detection, parity checking, and digital servo follow-up. Manufacture will be accomplished in Puerto Rico in connection with the "operation Bootstrap" industrialization program to develop that country's economy.

• Benson-Lehner Corporation has developed a new type decimal electronic counter; it employs a logical scheme which allows indication of true positive and negative numbers, with a single zero, and eliminates the problem of double zeros. The range of the counter is ± 99999 counts; it is available with a buffer storage unit capable of storing the indicated count at maximum counting rate. The buffer permits recording the indicated count on an output printer or card or paper tape punch. Input to this counter is from a Benson-Lehner photoelectric shaft to pulse converter. The counter has applications where electro-mechanical transducers are used for measuring physical quantities which may take on both positive and negative values, such as acceleration, velocity, position, temperature, etc.

• The PR-2 highspeed photoreader was introduced as a new accessory to the Bendix G-15 in September. It is now possible to tie the G-15 in with systems using teletype tape, NCR point-of-sale tape, or any punched paper tape using a 5, 6 or 7 channel numeric code. The photoreader's speed is 400 characters per second, and it will stop on a character. No leader or reload codes are required.

• The Hughes Aircraft Company Digitair, the first airborne digital computer in actual production, was developed for installation in jet airplanes. It performs automatic navigation, computes speed and altitude for *best* performance, and performs many other flight control functions based on coded information received from ground control stations and the plane's radar. It can maintain a check on available fuel and compute the distance which may be flown on it; it provides the pilot with target, range, azimuth, and elevation information; it dictates the proper speed and altitude for accurate interception of the target. The Digitair can complete 9,600 basic arithmetical computations in one second, 6,250 decisions in one minute, yet it weighs only 120 pounds and fits neatly into the cabinet of 21 inch table model TV set.

• The Corporation for Economic and Industrial Research in Arlington, Virgin a has announced that its IBM 709 Data Processing System is scheduled for delivery on or about January 31, 1959.

• The December, 1958 installation of a 704 at Douglas Aircraft Testing Division will make a total of three separate computing installations at the Santa Monica Division. The Douglas Missiles and Space Systems Engineering Department's second 704 went on-line on October 13.

• Northrop Aircraft, Incorporated, Hawthorne, California recently placed their order for an ALWAC III-E installation. The computer, which is scheduled for delivery in April, 1959, will be installed in the Manufacturing Department of Northrop for use in the development of perforated tape for the numerical control of machine tools.

• POGO (Program Optimizer for G-15 Operation), a fixed point compiler for the Bendix G-15 computer, has recently been introduced. This new compiler translates instructions of a general nature into a series of machine language commands and places them in optimum memory locations for minimum access timing. A simplified program is typed into the machine or read in from punched paper tape. The machine then generates the optimized machine language program which it records on a typewriter and on paper tape. This new compiler increases the flexibility of the G-15 by adding sixteen accumulators and eleven index registers to the basic machine facilities. Any one of the total of seventeen accumulators may be specified in a command. Also, the index registers may be assigned to any particular memory location, including the addresses of the accumulators. Facilities are included for de-bugging the machine language program from the typewriter keyboard.

• AIMACO, a new automatic programming technique, has recently been developed jointly by the Air Material Command and Remington Rand. This automatic compiler initially uses only 30 English verbs and employs the basic concepts of the Rem-Rand "Flow-Matic" system, modified and expanded to provide a means for programming single and multiple address, and fixed and variable word-length computers. The basis for the new system has already been machine tested; it is now in successful limited use. By the end of 1958 the system will be in general operation at all major AMC activities.

• The Cubic Corporation in San Diego recently installed a Bendix G-15 for development of a missile tracking application with ultimate delivery to Eglin Field. The G-15 is also being used in the safety impact prediction system at Camp Cooke.

• Italy and Germany have displayed keen interest in computing equipment that can provide short-cuts to problems in aircraft and guided missile programs, according to Paul Dennis of Bendix Computer. Dennis said his firm will install a unit at the University of Rome for the Italian Air Ministry to be used in an Italian missile program. He said major West German industrial plants such as Dornier, Zeiss and Zahnradfrabrik are vitally interested in this work. (Courtesy *Datamation*)

• Rapid identification of war or disaster victims can now be accomplished by feeding their skull measurements into an electronic computer. It took only two minutes to make a positive identification of a "victim" from among 498 suspects at the University of Pennsylvania Univac Computing Center. The method, developed by Dr. Viken Sassouni, is expected to be a great aid to military, police, insurance and disaster relief organizations.

• The Wyoming State Highway Department has ordered a Bendix G-15, equipped with the new CA-2 card coupling accessory, for use in earthwork computations. Wayne Day is in charge of the installation.

• On October 8, 1958, Pennsylvania became the first state in the nation to establish an electronic data processing center for all its departments and agencies. A UNIVAC computer system has been installed at Harrisburg, at a lease cost of $25,000 per month. Payroll for the Health Department will be the first application, and it is expected that in about one year, the computer will be in operation on a three-shifts-per-day basis.

• The October issue of the San Diego Computer Newsletter, published by the San Diego ACM chapter, carried an interesting article on Computer Programmed Automatic Testing. Charles Clower, a new ACM member, is working with the just forming Convair-Astronautics Product Support APCHE Card Deck and Card Deck Manual Group. He reports that "a number of new devices apply computer techniques to automatic test and checkout," and cites an example in the Automatic Programmed Checkout Equipment (APCHE), developed by RCA, to test the Atlas Weapon System by means of punched Remington Rand cards. The article mentions "that Rocketdyne tests rocket engine assemblies with a

somewhat similar device developed by Autonetics. RACE, Sperry Rand's Rapid Automatic Checkout Equipment, which naturally also uses Remington Rand card decks, although it can be made to operate from punched tape or magnetic tape, test radars, data handling systems, and others. IBM has just announced a completely automatic system to test SAGE printed circuit components. A proposed GE device for automatic fire control system testing would employ punched tape and a digital voltmeter. Other companies in the field include Sunstrand Turbo, Color Television, Electro Instruments, Farnsworth, Motorola, Northrop Aircraft, Polrad, and San Diego's Stromberg-Carlson. Daystrom Systems of La Jolla, California recently announced receipt of a study contract for automatic medical diagnosis."

• Ronald J. R. Kallman has been named to the newly created position of Western Regional Manager for TRANSAC computer systems by Philco Corporation's Government and Industrial Division.

• Dr. Hansjorg Oser has recently joined the staff of the Computation Laboratory at the National Bureau of Standards where he is concerned with high speed computer mathematics, including the analysis of problems for the Bureau's IBM 704 computer.

• Frank E. Tidball, formerly with Remington Rand Univac, has joined General Kinetics, Incorporated in Arlington, Virginia as Staff Electrical Engineer. Mr. Tidball will act as a consultant in the installation and maintenance of large-scale computer systems.

• R. W. Westerfield, formerly Assistant to the President of Hoffman Electronics, has recently accepted the position of General Manager at ALWAC Computer Division, El-Tronics, Inc., Hawthorne, California. Also at ALWAC, Victor White has been named Products Manager, and Hugh Landrum has become Chief of Systems Acceptance.

• Dr. Edward K. Blum has recently been appointed Associate Director of the Computation and Data Reduction Center of Space Technology Laboratories in Los Angeles, California.

• Lawrence A. Connell, formerly with the U. S. Air Force, and now a sales technical representative with the ElectroData Division of Burroughs Corporation, was recent y presented a Commendation Ribbon for his work in converting Air Force personnel accounting procedures from conventional punched-card equipment to electronic data processing equipment.

• Recent additions to the firm of Bonner and Moore Engineering Associates in Houston, Texas include Dale O. Cooper, formerly of the Union Oil Company and Louis P. Karvelas, formerly of Humble Oil and Refining Company. Their new duties will involve the application of Operations Research and computer techniques to the solution of problems in refinery operations (scheduling, process design, and economic analysis).

• Dr. Eugene M. Grabbe, senior staff consultant on automation, The Ramo-Wooldridge Corporation, will head the United States Exhibits Committee for the International Conference on Information Processing, to be held in Paris, France, June 13–22, 1959. Organized by the United Nations Educational, Scientific and Cultural Organization (UNESCO), this will be the world's first global conference and exhibit on computers. Serving with Dr. Grabbe on the Exhibits Committee will be L. David Whitelock, Navy Department, Bureau of Ships; Ralph Mork, IBM World Trade Headquarters; Paul A. Dennis, Bendix Computer Division; and David Weinberg, of The Ramo-Wooldridge Corporation.

• Lowell S. Bensky has been appointed head of the Digital Systems Engineering Department at Reese Engineering, Inc. in Philadelphia, Pennsylvania. This newly created department will provide complete service from consultation to systems assembly with particular emphasis on special data handling equipment.

• Mr. W. Hoover has recently been promoted to the position of Section Chief of a new section, Applied Mathematics, at the Jet Propulsion Laboratory of the California Institute of Technology. Included in his responsibilities are the operation of the Datatron digital computer and the newly installed IBM 704 computer.

• Recent additions to the Technical Staff of the Computation and Data Reduction Center at Space Technology Laboratories in Los Angeles, California include Francis Buismato, Peter Engel, William Green, Ray Orth, and Beverly Washburn.

• Donald L. Benscoter has been named Dallas District Manager for the Burroughs Corporation's ElectroData Division. Mr. Benscoter is in charge of sales and service of Burroughs E101, 205, and 220

electronic computers and data processing systems in the South Central states from Mississippi to New Mexico.

• Dr. Robert D. Huntoon has recently been appointed Deputy Director of the National Bureau of Standards, U. S. Department of Commerce. In this post, Dr. Huntoon will serve as alternate to the Director in external matters, and will exercise day-to-day direction and review of Bureau programs.

• Mr. Robert D. Cruickshank, formerly of the Crosley Division of the AVCO Manufacturing Company, has recently joined the Flight Propulsion Laboratory of the General Electric Company in Cincinnati as a Statistical Analyst.

• Donald P. Moore, who will be remembered by readers of *Computing News* as the author of SCHROMP (a program for binary-octal conversion that operates in negative time), and SCHROMP^2 (a program to reconvert octal to binary), has joined the Western Data Processing Center staff. He plans to work towards a Ph.D. in mathematics while doing full-time programming for the WDPC.

• Recent appointments in the Engineering Division of The Thompson-Ramo-Wooldridge Products Company in Los Angeles include: Charles G. Laspe, Associate Manager of the Process Applications Department (which conducts joint applications studies with petroleum refining, chemical, and other companies in the process industries to plan computer control systems); and Harold S. Keit, Associate Manager of the Data Processing and Controls Department.

• Joseph K. Slap, Assistant General Manager of ALWAC Computer Division of El-Tronics, Inc., Hawthorne, California described how "Electrons Can Calculate" to the American Society of Lubrication Engineers, Los Angeles Section, at its November 19 meeting. Using a "block diagram for vice presidents" Mr. Slap simplified the concepts of computer control, memory, and information flow, for the layman without a background in electronics or higher mathematics.

• Fred Tonge, from Carnegie Institute in Pittsburgh, is now working on a complex information processing project at the RAND Corporation.

• "Basic Concepts of Information Retrieval" is the first of a series of papers aimed at providing a broad theoretical foundation for the problem of information retrieval of electronic computers. This initial document, designed to help fill the need for a standardized point of view from which to evaluate different systems or to design new systems satisfying given requirements, is the result of research being conducted by Dr. John W. Mauchly, Director of Univac Applications Research Center, Philadelphia and supported by the Office of Naval Research. A copy of the paper (UC 892) can be obtained by writing Remington Rand Division of Sperry Rand Corporation, 315 Fourth Avenue, New York 10, New York. Future papers will cover standard models of information retrieval systems; representation and storage of information; quantization of various "components of meaning"; general theory of transformations of representations applied to information retrieval; automatic programming and language translation; sensing devices as information transformers; quantitative measures of retrieval system characteristics; and design of retrieval systems.

Another manual (UC 897) published by Remington Rand describes in detail how a women's specialty store in Southern California uses a Univac 60 punched-card electronic computer for customer charge accounting.

• "Digital Control Computer" is a four-page reference bulletin describing the RW-300 Computer. Process control, data logging, pilot plant and test facility applications for computer control systems are discussed, and detailed specifications are listed. For a copy of this bulletin, write to The Thompson-Ramo-Wooldridge Products Company, P. O. Box 45067, Airport Station, Los Angeles 45, California.

• First installations of the Burroughs 220 were accomplished during October. The ElectroData Division also announced a one-week sales record of $3,000,000 in electronic computer orders booked during the final week of September.

• A new 61,500 square foot card manufacturing plant located in Sherman, Texas, was recently dedicated by International Business Machines Corporation. The plant produces punch cards for IBM's data processing machine customers in the Southwest. IBM also recently dedicated its new 570,000 square foot manufacturing plant at Rochester, Minnesota. The advanced facility houses a work force of 1,800 people who produce twenty-one different models of data processing machines, including card punches, collators and interpreters.

• Servomechanisms Inc., Hawthorne, California has received an order amounting to nearly a half-million dollars from Lockheed Aircraft for production of true airspeed computers.

• Computer Equipment Corporation is the new name for the Company formerly known as Digitron, Inc. The name change was effected "in order to clarify the nature of the business in which our growing electronic firm is engaged," according to A. C. Bellanca, president of the Los Angeles firm.

• IBM, Extension Suisse, opened a data processing center in Zurich at the end of May. The center has an IBM 650 electronic computer and a staff of twelve scientists and engineers under the supervision of Dr. Jakob Haller.

• Development, production and maintenance of several new guided missile computers for the Nike-Zeus anti-missile Missile Program are included in a $20,000,000 order awarded recently to Remington Rand Univac. Remington Rand will work with Bell Telephone Laboratories for Army Ordnance on this new Department of the Army development.

• Net income of the International Business Machines Corporation for the nine months ended September 30, 1958 was $91,453,043 after estimated U. S. federal income taxes. This is equivalent, for the nine months' period, to $7.72 a share on the 11,841,946 shares outstanding at the end of the period.

• The Long Island Computer Association held its first meeting on October 14 in Garden City, New York. Dr. Grace Murray Hopper, Director of Automatic Programming Research, Remington Rand Univac spoke on the topic, "Present Status of Automatic Programming." This new organization has been established to keep its members informed of changing electronic computer applications and developments. Representatives from the following organizations participated in its formation: Adelphi College, American Bosch Arma Corporation, Brookhaven National Laboratories, Fairchild Engine and Airplane Corporation, Grumman Aircraft Engineering Corporation, International Business Machines Corporation, Republic Aviation Corporation and Sperry Rand Corporation. Arnold B. Schacknow, Director of the Computational Laboratory of the Arma Division of the American Bosch Arma Corporation, served as Chairman of the initial meeting.

The December 17 meeting of the LICA will be held at 8:00 p.m. in the Flight Room at Roosevelt Field, Garden City. Dr. Herman Goldstein will speak. For additional information contact Dr. A. Finerman, Republic Aviation, Telephone CH 9-1100, Extension 8112.

• The September/October issue of Datamation reports that data processing equipment users in Stockholm, Sweden, have formed an Integrated Data Processing Group composed of about forty members. Secretary is Peter Hansen of the Swedish Commerce Bank. Exchange of ideas, visits to installations, keeping up with latest changes, and exploring technical data, are some of the targets which this group has set for itself. The IDP group idea is making huge strides and certainly its future is very promising.

• "Some Business Research Problems" was the topic of Dr. George W. Brown at the October meeting of the Digital Computers Association in Los Angeles, California. Dr. Brown, Director of the Western Data Processing Center and Professor of Business Administration at UCLA, discussed many problems currently being handled on computers. He also examined various difficulties encountered in attempts to solve certain problems, such as value judgment questions, not yet applicable to computers.

• At the October 8 meeting of the Instrument Society of America, Chester G. Hylkema of Jet Propulsion Laboratory, California Institute of Technology spoke on "The Key Role of Computers in the Moon Probe Missile." Mr. Hylkema explained how computers are used to save millions of dollars in the missile and satellite programs, how missiles can be "flown" on computers, and how some of the "bugs" are worked out before launching.

• "Preparation for Electronic Data Processing" was the topic of the address given by Mr. C. C. Hilsee, Western Region Electronic Data Processing Special Representative, International Business Machines Corporation, at the October meeting of the American Institute of Industrial Engineers. Mr. Hilsee covered in detail a practical guide to the planning, manning, scheduling, budgeting for and applying Electronic Data Processing (E.D.P.). Such items as the conversion of existing clerical operations for ultimate changeover to electronic data processing equipment and methods were explored. The problems of coordinating interlocking features of a system involving independent subsidiary companies' activities and building of timetables for installation which will avoid interruption of existing daily operating requirements were also examined.

• The 33rd Annual Fall Meeting of the California Natural Gasoline Association was devoted to a symposium on the use of electronic computers in the petroleum industry. Seven companies exhibited computers and data processing equipment for this application. Dr. Joseph F. Manildi, General Manager of The Thompson-Ramo-Wooldridge Products Company in Los Angeles, spoke on "Computer Control of Production Processes" at the management luncheon prior to the symposium.

• On November 8 the American Management Association Game was run on the Engineering Research and Development Laboratory computer at Fort Belvoir, Virginia, with the Army Management School participating.

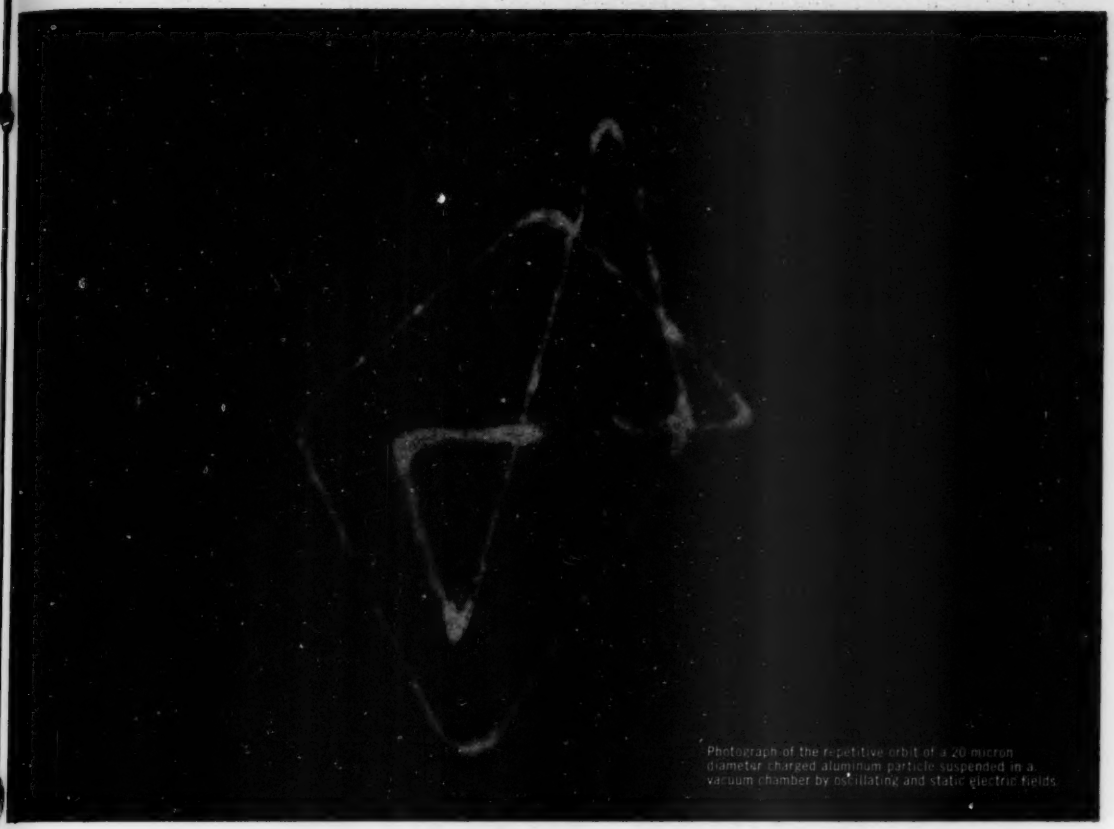
• Representatives of twelve countries attended the International Conference on Scientific Information at the Mayflower Hotel in Washington, D. C., November 16–21. Sponsored by the National Academy of Sciences, National Research Council, National Science Foundation and the American Documentation Institute, the conference was divided into seven areas, morning and afternoon sessions, during which the papers of scientists of various countries were presented and discussed. Area One proposed the knowledge now available and the methods of ascertaining scientists' requirements for scientific literature and reference services; Area Two covered the function and effectiveness o abstracting and indexing services for storage and retrieval of scientific information; Area Three—the effectiveness of scientific monographs, compendia, and specialized information centers in meeting the needs of scientists; Area Four—organization of information for storage and search . . . comparative characteristics of existing systems; Area Five—the organization of knowledge for storage and retrospective search: intellectual problems and equipment consideration in the design of new systems; Area Six—the organization of information for storage and retrospective search: possibility for a general theory of storage and search; and Area Seven—the responsibilities of governmental bodies, professional societies, and other groups to provide improved information services and promote research in documentation.

COMING EVENTS

- Eastern Joint Computer Conference
  December 3–5, 1958; Bellevue-Stratford Hotel, Philadelphia, Pennsylvania
  Contact: John Broomall, Dev. Engr., Burroughs Corporation, Research Center, Paoli, Pennsylvania (General Chairman); F. M. Verzuh, Asst. Director, Computation Center, M.I.T., Cambridge, Massachusetts (Technical Program Chairman)
- Mid-America Electronics Convention
  December 9–10; Municipal Auditorium, Kansas City, Missouri
  Contact: Wilbert O'Neal, Vendo Co., 7400 E. 12, Kansas City, Missouri
- USE Meeting
  December 10–12, 1958; El Paso, Texas
- Annual Meeting of American Association for Advancement of Science
  December 26–31, 1958; Washington, D. C.
  Sponsor: ACM (for December 30, 1958 session, 2:00 p.m.), Congressional Room, Statler Hotel, Washington, D. C.
- American Mathematical Society Meeting (65th Annual)
  January 20–22, 1959; University of Pennsylvania, Philadelphia, Pennsylvania
- Transistor and Solid State Circuits Conference
  February 12–13, 1959, University of Pennsylvania, Philadelphia, Pennsylvania
  Contact: Arthur B. Stern, General Electric Company, Building 3, Syracuse, New York
  Sponsor: PGCT, AIEE and the University of Pennsylvania
- SHARE XII Meeting
  February 17–20, 1959; Statler Hotel, New York
- American Mathematical Society Meeting
  February 28, 1959; New York, New York
- Western Joint Computer Conference
  March 3–5, 1959; Fairmont Hotel, San Francisco, California

Contact: M. L. Lesser, IBM Research Lab, San Jose, California
Sponsor: PGEC, AIEE, ACM

- USE Meeting
  April 1–3, 1959; Chicago, Illinois
- American Mathematical Society Meetings
  April, 1959; Monterey, California
  April, 1959; New York, New York
- Joint Meeting of Institute of Mathematical Statistics (Central Region) and the Association for Computing Machinery
  April 2–4, 1959; Case Institute of Technology, Cleveland, Ohio
  Contact for IMS: Martin B. Wilk, Bell Telephone Labs, Murray Hill, New Jersey
  Contact for ACM: Daniel Teichroew, National Cash Register, Dayton 9, Ohio
- Interdisciplinary Conference on Self-Organizing Systems
  May 5–6, 1959; Museum of Science and Industry, Chicago, Illinois
  Sponsor: Information Systems Branch, Office of Naval Research and Armour Research Foundation of Illinois Institute of Technology
  Contact: S. H. Cameron, ICSOS Conference Secretary, Armour Research Foundation, 10 W. 35 Street, Chicago 16, Illinois
- 1959 Electronic Components Conference, "New Concepts for the Space Age"
  May 6–8, 1959; Benjamin Franklin Hotel, Chestnut Street at 9th, Philadelphia, Pennsylvania
  Sponsors: AIEE, IRE, EIA, WCEMA
  Contact: Bernard Osbahr or John Hickey, Electronic Industries, Chestnut and 56 Street, Philadelphia 39, Pennsylvania
- First International Conference on Information Processing (ICIP)
  June 15–20, 1959; Paris, France
  Sponsor: UNESCO
  Contact for U. S. Committee of ICIP: A. S. Householder, Chairman, U. S. Program Committee, Oakridge National Labs, P. O. Box X, Oakridge, Tennessee
- 1959 ACM National Conference
  Summer, 1959; Massachusetts Institute of Technology, Cambridge, Mass.
  Contact: F. Verzuh, M.I.T., Computation Center, Cambridge, Mass.
- American Mathematical Society Meetings
  June, 1959; Far West
  Summer, 1959; Salt Lake City, Utah
- SHARE XIII Meeting
  August 18–21, 1959; Olympic Hotel, Seattle, Washington
- American Mathematical Society Meeting
  November, 1959; Detroit, Michigan
- Eastern Joint Computer Conference
  1959; Boston, Massachusetts
- SHARE XIV Meeting
  February, 1960, Los Angeles, California
- Second Interkama—International Congress and Exhibition for Measuring Techniques and Automation
  October 19–26, 1960



Photograph of the repetitive orbit of a 20 micron diameter charged aluminum particle suspended in a vacuum chamber by oscillating and static electric fields.

ELECTRODYNAMIC ORBITS

By the application of properly chosen alternating and static electric fields, electrically charged particles can be maintained in dynamic equilibrium in a vacuum against interparticle and gravitational forces. This is illustrated in the above photograph of the orbit of a charged dust particle. During the time of exposure the particle traversed the closed orbit several times, yet it retraced its complicated path so accurately that its various passages can barely be distinguished.

The range of particles of different charge-to-mass ratios which can be contained in this manner is determined by the gradients of the static and alternating electric field intensities and by the frequencies of the latter. In the absence of static fields and for a given electric field strength, the minimum frequency required for stable containment of the particles is proportional to the square root of their charge-to-mass ratios. Thus, charged colloidal particles require the use of audio frequencies, atomic ions need HF frequencies, while electrons require the use of VHF and higher frequencies.

Under the confining influence of the external fields, the particles are forced to vibrate with a lower frequency of motion which is determined by the external field intensities, space charge, and the driving frequencies. If the initial thermal energy is removed, a number of particles may be suspended in space in the form of a crystalline array which reflects the symmetry properties of the external electrodes. These "space crystals" can be repeatedly "melted" and re-formed by increasing and decreasing the effective electrical binding force. These techniques offer a new approach in the study of plasma problems and mass spectroscopy in what may be properly termed "Electrohydrodynamics."

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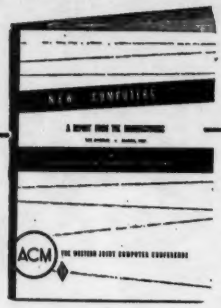
The Ramo-Wooldridge Corporation

LOS ANGELES 45, CALIFORNIA



NEW COMPUTERS

. . . A Report from the Manufacturers

Do you know the design and application characteristics of these machines

NCR-304

DATATRON

BIZMAC II

UNIVAC X-308

STRETCH

PHILCO S-2000

ALWAC 800

IBM 709

?

These nine computer systems—the newest advancements in the art of computing—so new that most of them have not yet been delivered to the customers—are completely described in "New Computers—A Report from the Manufacturers," the proceedings of the March, 1957 technical symposium sponsored by the Los Angeles Chapter of the Association for Computing Machinery.

Copies (8½ x 11, 138 pages) may be ordered from the Association for Computing Machinery, 2 East 63 Street, New York 21, New York. Price $2.50 per copy.

Man-Machine Relationships: A New Field for Computer Programmers

A new field for Computer Programmers has arisen from System Development Corporation's work on relationships of men and complex machine systems.

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Please include previous address

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Statement required by the Act of August 24, 1912, as amended by the Acts of March 3, 1933, and July 2, 1946 (Title 39, United States Code, Section 233) showing the ownership, management, and circulation of COMMUNICATIONS OF THE ASSOCIATION FOR COMPUTING MACHINERY published monthly at Philadelphia, Pennsylvania, for October 1, 1958. 1. The names and addresses of the publisher, editor, managing editor, and business manager are: Publisher, None. Editor, Alan J. Perlis, Carnegie Institute of Technology, Pittsburgh 13, Pa. Managing editor, Saul Rosen, Philco Corporation, 4700 Wissahickon Ave., Phila. 44, Pa. Business manager, Saul Rosen, Philco Corporation, 4700 Wissahickon Ave., Phila. 44, Pa. 2. The owner is Association for Computing Machinery, Inc., 2 E. 63rd Street, New York 21, New York; None. 3. The known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None. 4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner. 5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: (This information is required from daily, weekly, semiweekly, and triweekly newspapers only.) (Monthly publication.)

SAUL ROSEN, Business Manager

Sworn to and subscribed before me this 26th day of September, 1958.

JOHN J. SUBACUS
Notary Public,
Philadelphia, Philadelphia Co.

(My commission expires February 8, 1961)

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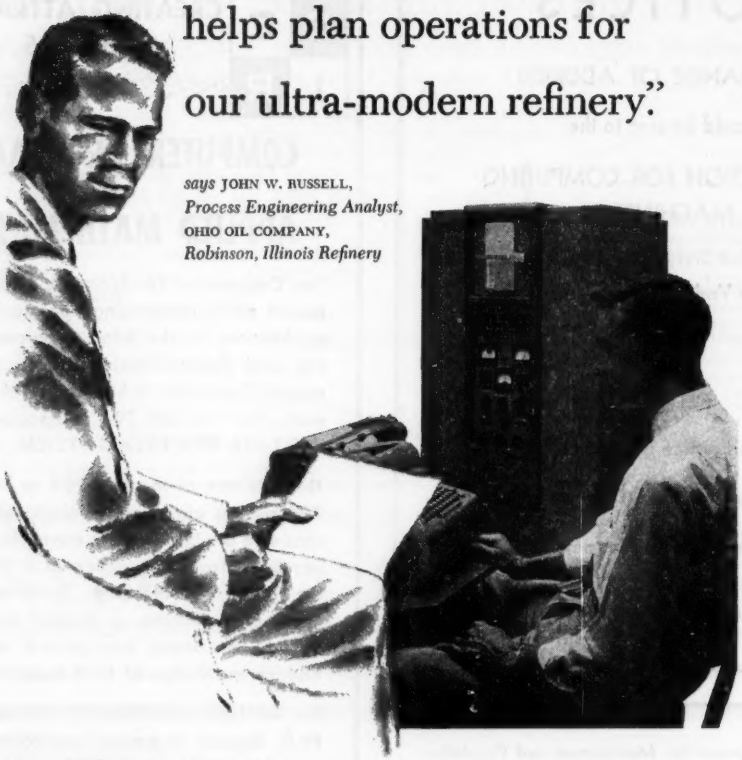
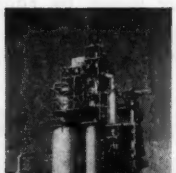


says JOHN W. RUSSELL,
Process Engineering Analyst,
OHIO OIL COMPANY,
Robinson, Illinois Refinery



"In the highly competitive oil industry, efficiently planned refinery operation is a must. To handle the complex mathematics involved in this planning, we needed the speed of electronic computing. After careful study, we have installed a Bendix G-15 and although it is one of the lowest priced machines, we are using it very successfully on large scale problems. We like the compact size and have found reliability to be exceptional. G-15 users share valuable programs through their own organization, too, and this adds materially to the computer's value.".

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Many of the engineering problems encountered require the development of new mathematical techniques in order to use the digital computer in determining numerical solutions. Positions now exist for persons to carry on research projects in numerical analysis and to apply advanced numerical techniques to engineering problems. A Ph.D. in Mathematics or an M.S. with experience and U.S. Citizenship are required.

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SYSTEMS ANALYSIS
Significant experience is required in analysis of large-scale digital systems or in computer programming.

PROGRAMMING
At least one year of experience is required in programming of digital machines.

ELECTROMECHANICAL DESIGN
Experience in electromechanical component design related to digital computer systems is essential.

TRANSISTOR CIRCUIT DESIGN
Applicants should have transistor applications experience in computer circuit design.

LOGICAL DESIGN
Experience in logical design of digital systems is necessary.

INFORMATION DISPLAY
Experience in create development of large-scale information displays is required.

PHILADELPHIA APPOINTMENTS

can be arranged by calling Mr. Frank C. Nagel collect at PEnnypacker 5-8698, Wednesday through Friday, December 3–5, or inquiries can be addressed to Mr. Nagel at

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Must be able to understand broad aspects of a problem as well as the application of details. Requires knowledge of digital computers so that problems may be organized for application and analytical ability in logical application and deductive reasoning. Minimum of two to three years of experience with broad range of interests.

RESEARCH AND DEVELOPMENT ENGINEERS

Electrical engineers or physicists experienced in design and/or development of computing or pulse equipment.

SENIOR PROGRAMMING ANALYSTS

Experienced in programming for large scale computers, such as IBM 704, 709, or 650, Univac, or Datatron. Experienced with compliers and automatic coding techniques. Ability to analyze complex, non-routine, non-numerical problems for programming. Also ability to assist work of junior programmers. Minimum three years of experience.

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Experience with compilers and automatic programming. Ability to draw detailed flow charts and code and direct coders. Two years large scale computer experience.

A government security clearance is required of all project personnel.

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